INSTRUCTION MANUAL

POWER SUPPLY

MODEL 4005/4005R SERIAL _____

Power Designs inc.

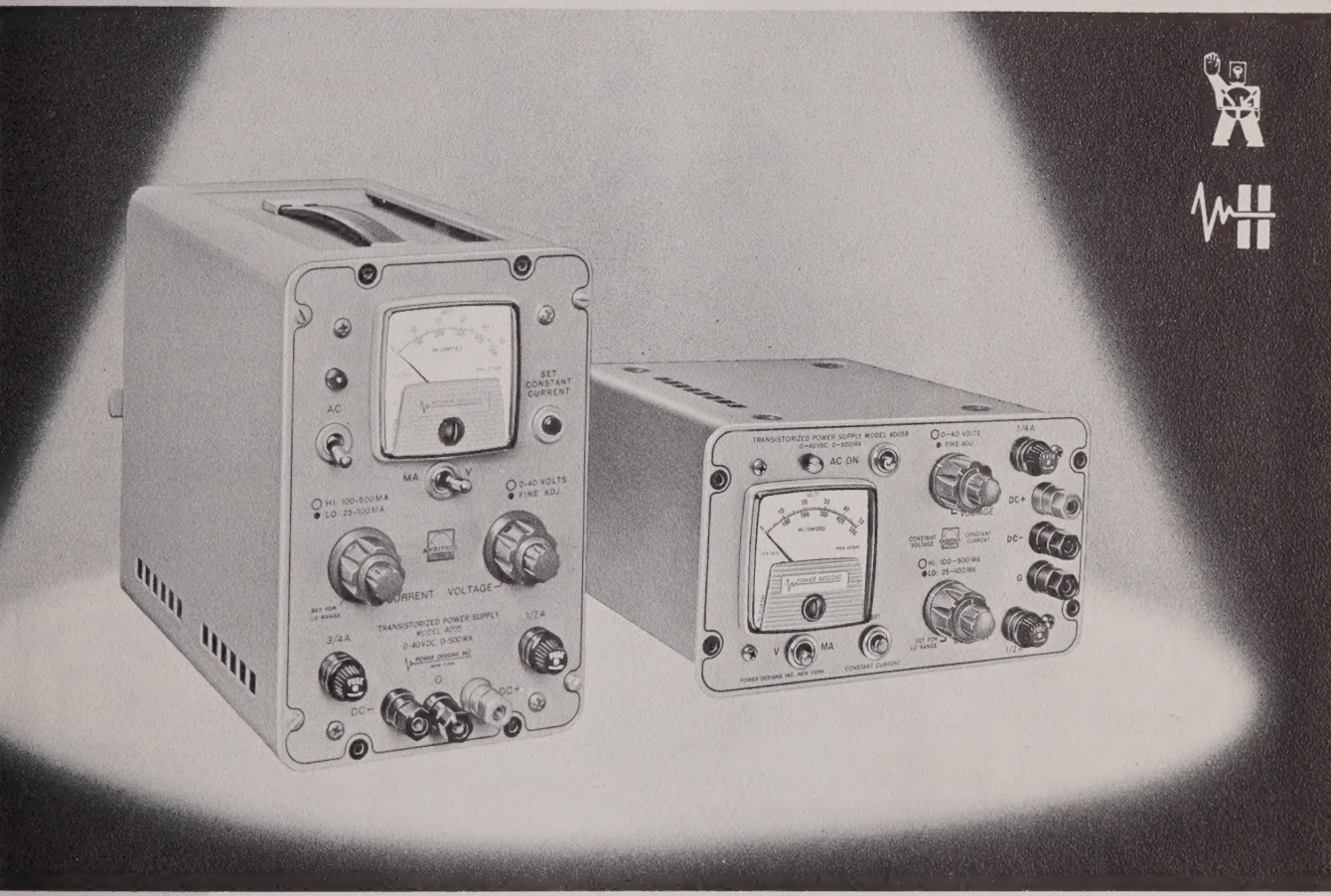
1700 SHAMES DRIVE, WESTBURY, N. Y.

MODEL **4005** 0-40 VDC • 0-0.5A

MODEL **4005R** 0-40 VDC • 0-0.5A

SEMICONDUCTORIZED
POWER SUPPLY

POWER DESIGNS



UNIVERSAL CONSTANT VOLTAGE / CURRENT POWER SUPPLY

WITH AMBITROL®

RECOGNIZED RELIABILITY

MODEL 4005 — 0-40 VDC • 0-0.5A

MODEL 4005R — 0-40 VDC • 0-0.5A

MODES OF OPERATION:

- Constant Voltage Regulation
- Constant Current Regulation
- Remote Voltage Programming
- Remote Current Programming
- Automatic Transfer from Voltage to Current Regulation at any Operating Point.
- Automatic Transfer from Current to Voltage Regulation at any Operating Point.
- Constant Voltage Regulation with Continuously Adjustable Current Limiting.
- Constant Current Regulation with Continuously Adjustable Voltage Limiting
- Series Operation
- Parallel Operation

APPLICATIONS

- Versatile laboratory power source with controlled regulation from no load to a short circuit.
- Precision automatic battery charger for sealed batteries. Control accuracy of 0.1%.
- Safety power supply for component protection in experimental circuitry.
- Supplementary power source to increase capacity of an external d-c supply. Voltage locks in automatically.
- Automatic Test Set power supply for current limited or voltage limited testing of semiconductor devices.
- Current and Voltage controlled source for electroplating, tantalum capacitor forming and other electro-chemical processes.
- Controlled power source for electrophoresis, microbiological and chemical analysis.

ELECTRICAL SPECIFICATIONS

MODEL 4005 & MODEL 4005R

CONSTANT VOLTAGE

RANGE: 0-40 vdc, 0-500 milliamperes, continuously adjustable.

REGULATION: .05% or 10 millivolts max., whichever is greater for line or load variations.

RIPPLE: .0005% or 250 microvolts maximum.

RESPONSE TIME: Less than 50 microseconds for 100% step changes in rated load.

SOURCE IMPEDANCE: 0.1 Ω to 20 kc, 0.7 Ω to 1 mc.

STABILITY: Less than 10 millivolts drift per 24 hours at constant ambient temperature with fixed load and external low temperature coefficient programming resistor.

TEMPERATURE COEFFICIENT: D-C output voltage change less than .02% per degree Centrigrade.

REMOTE PROGRAMMING RESISTANCE: 100 Ω per volt.

VOLTAGE CONTROL: Dual concentric fine and coarse adjustment with five millivolts resolution.

CONSTANT CURRENT

RANGE: 25-500 milliamperes, continuously adjustable.

REGULATION: .02% or 100 microamperes, whichever is greater, for line or load variations down to a short circuit across the output terminals.

VOLTAGE COMPLIANCE: 40 volts maximum.

RIPPLE: Ripple component of the output current less than .005% or 20 microamperes, whichever is greater.

SOURCE IMPEDANCE: 400,000 Ω approx.

STABILITY: Less than 0.1% or 250 microamperes drift per 24 hours at constant ambient temperature with fixed load and low temperature coefficient external programming resistor.

TEMPERATURE COEFFICIENT: D-C output current change less than .08% per degree Centigrade change in ambient.

INPUT: 105-125 VAC 55-440 ~, single ϕ

OPERATING TEMPERATURE: 0-50°C.

OUTPUT TERMINALS: Front panel binding posts and rear access terminal strip. Either positive or negative output terminal may be grounded.

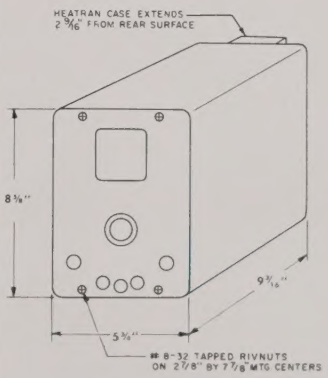
10M 5-63 PRINTED IN USA

Universal DC POWER SUPPLIES WITH AMBITROL®

DESIGN FEATURES

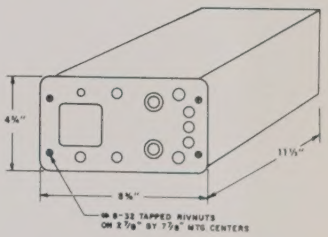
- ®AMBITROL Dual amplifier control system permits continuous control of voltage or current with automatic electronic crossover to either mode of operation.
- ®HEATRAN Electronic power transistor dissipation control.
- Performance specifications based on anticipated ratings at end of five years of service life.
- Silicon planar diffused junction input transistors provide high stability.
- Pre-aged transistors with "reliability controlled" parameters for insured long life.
- Avalanche protected Silicon rectifiers to prevent line surge failures.
- Automatic Ico compensation circuit eliminates the possibility of turn-on and turn-off transients.
- Dual concentric controls for coarse and fine voltage or current adjustment.
- Front and rear access output terminals.
- Silicon diode voltage references operating in the zero temperature coefficient region.
- Semiconductor devices derated to 50% of rated voltage and current.
- Volt-ammeter monitors output voltage or current.
- Computer quality electrolytic capacitors.
- Line and load circuits separately fused. Accessible at front panel.
- Fifty hour pre-aging of power supplies prior to test guarantees field service reliability.
- Modular package construction suitable for rack mounting. Single or dual mounting of Model 4005R in 5¼" x 19" panel. Single, dual, or triple mounting in standard 8¾" x 19" panel. See catalogue RPA-62 for rack panel adapters.

MECHANICAL SPECIFICATIONS



MODEL 4005

WEIGHT: 11½ lbs.



MODEL 4005R

WEIGHT: 9 lbs.

FINISH: Brushed anodized natural aluminum panel with etched black lettering. Cabinet finished in grey wrinkle enamel. Chassis and dust cover, golden irridite.

MODEL 4005 ..... **$143.50** FOB FACTORY

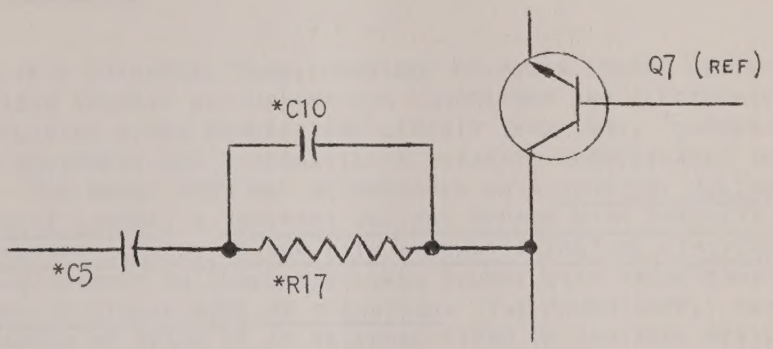
MODEL 4005R ..... **$149.50** FOB FACTORY

Power Designs inc.
1700 SHAMES DRIVE, WESTBURY NEW YORK
516 EDgewood 3-6200 TWX: 516 333-5698

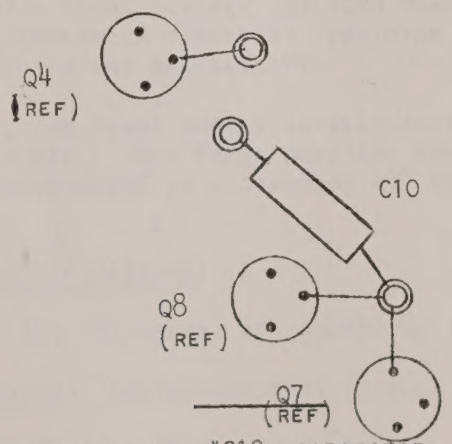
FEBRUARY 5, 1964

ADDENDA

CAPACITOR C10 HAS BEEN ADDED TO THE STABILIZATION NETWORK PARTS IDENTIFIED WITH * ON THE SCHEMATIC DIAGRAM. C10 IS CONNECTED IN PARALLEL WITH R17 AS SHOWN BELOW:

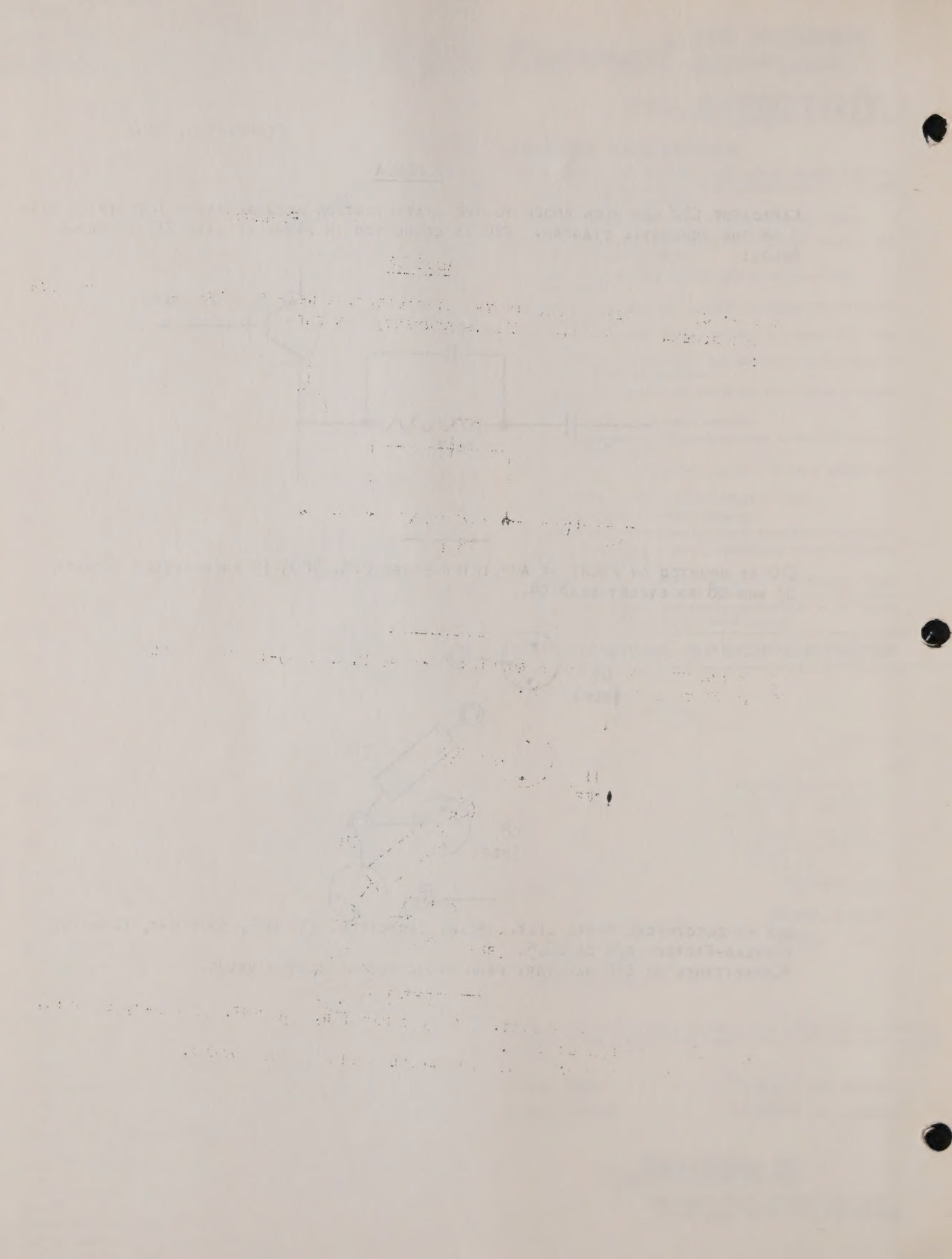


C10 IS MOUNTED ON FRONT OF AMPLIFIER BOARD P.S. 4005-19 FROM EYELET BETWEEN Q7 AND Q8 TO EYELET NEAR Q4.



ADD TO ELECTRICAL PARTS LIST. *C10, CAPACITOR, 330 MMF, 500V D-C, CERAMIC, TUBULAR-FACTORY P/N CC 26.5.

*CAPACITANCE OF C10 MAY VARY FROM ABOVE DESIGN CENTER VALUE.



OCTOBER 1962

INSTRUCTION MANUAL

FOR

MODEL 4005

TRANSISTORIZED POWER SUPPLY

1. GENERAL DESCRIPTION:

THE MODEL 4005 IS A UNIVERSAL TRANSISTORIZED DC POWER SOURCE DESIGNED TO FURNISH STABILIZED VOLTAGE OR CURRENT FOR LABORATORY AND ELECTRONIC INSTRUMENTATION. EMPLOYING A NEW PROPRIETARY CIRCUIT TECHNIQUE, TRADEMARKED *AMBITROL, THE EQUIPMENT HAS A VERSATILITY HITHERTO UNOBTAINABLE IN A SINGLE DEVICE. THE MODEL 4005 MAY BE OPERATED AS A CONSTANT VOLTAGE SOURCE, A CONSTANT CURRENT SOURCE, A CONSTANT VOLTAGE SOURCE WITH AUTOMATIC CURRENT LIMITING, A CONSTANT CURRENT SOURCE WITH AUTOMATIC VOLTAGE LIMITING, OR A CONSTANT VOLTAGE/CURRENT OR CURRENT/VOLTAGE SOURCE WITH PREDETERMINED ELECTRONIC CROSSOVER TO EITHER MODE OF OPERATION. THE POWER SUPPLY MAY ALSO BE REMOTELY PROGRAMMED BY MEANS OF AN EXTERNAL FIXED OR VARIABLE RESISTANCE TO PROVIDE ANY DESIRED REGULATED OUTPUT VOLTAGE, CURRENT OR PREDETERMINED TRANSFER TO EITHER MODE.

THE MODEL 4005 HAS BEEN MANUFACTURED SINCE JUNE OF 1960. THE POWER SUPPLY BEARING THE SERIAL NUMBER ON THE COVER OF THIS MANUAL IS AN IMPROVED UNIT EMPLOYING THE NEW SEMICONDUCTOR DEVICES UNAVAILABLE AT THE INCEPTION OF THE ORIGINAL EQUIPMENT. THESE DEVICES (SILICON PLANAR DIFFUSED JUNCTION TRANSISTORS) PERMIT DC AMPLIFIER CIRCUITRY PROVIDING A MAJOR IMPROVEMENT IN PERFORMANCE, STABILITY AND RELIABILITY.

COMPACT AND LIGHT, THE POWER SUPPLY IS SELF-CONTAINED IN A PORTABLE CABINET DESIGNED FOR BENCH USE. RACK PANEL ADAPTERS ARE AVAILABLE FOR MOUNTING ONE TO THREE UNITS SIDE-BY-SIDE IN A STANDARD 19" RELAY RACK WITH A PANEL HEIGHT OF 8 3/4".

2. ELECTRICAL SPECIFICATIONS:

2.1 INPUT: 105-125 VOLTS, AC, 55-440 ~, 1Ø, 45 WATTS.

2.2 TEMPERATURE: CONTINUOUS DUTY AT FULL LOAD 0-50°C AMBIENT.

2.3 CONSTANT VOLTAGE SPECIFICATIONS:

2.3.1 OUTPUT: 0-40 VOLTS DC, CONTINUOUSLY VARIABLE, AT 0-500 MILLIAMPERES. A DUAL CONCENTRIC CONTROL FOR BOTH COARSE AND FINE ADJUSTMENT PROVIDES A RESOLUTION OF BETTER THAN 5 MILLIVOLTS.

2.3.2 REGULATION: 0.05% OR 10 MILLIVOLTS MAXIMUM, WHICHEVER IS GREATER, FOR LINE OR LOAD VARIATIONS OVER THE OPERATING RANGE.

2.3.3 RIPPLE: .0005% OR 250 MICROVOLTS MAXIMUM.

*PATS. APPLIED FOR.

2.3.4 SOURCE IMPEDANCE: 0.1 Ω TO 20KC, 0.7 Ω TO 1 MC.

2.3.5 RESPONSE TIME: LESS THAN 50 MICROSECONDS FOR 100% STEP CHANGE IN RATED LOAD.

2.3.6 REMOTE PROGRAMMING RESISTANCE: 100 Ω PER VOLT OF OUTPUT.

2.3.7 STABILITY: LESS THAN 10 MILLIVOLTS DRIFT PER 24 HOURS AT CONSTANT AMBIENT TEMPERATURE WITH FIXED LOAD AND FIXED LOW TEMPERATURE COEFFICIENT EXTERNAL PROGRAMMING RESISTOR.

2.3.8 TEMPERATURE COEFFICIENT: DC OUTPUT VOLTAGE CHANGE LESS THAN .02% PER °C CHANGE IN AMBIENT.

2.4 CONSTANT CURRENT SPECIFICATIONS:

2.4.1 OUTPUT: 25-500 MILLIAMPERES, CONTINUOUSLY ADJUSTABLE. A DUAL CONCENTRIC CONTROL PERMITS ADJUSTMENT IN TWO OVERLAPPING RANGES: 25-100 AND 100-500 MILLIAMPERES. THE RESOLUTION OF THESE CONTROLS IS IN THE ORDER OF 4% OF A GIVEN CURRENT SETTING.

2.4.2 VOLTAGE COMPLIANCE: OUTPUT CURRENT CONSTANT TO FULL RATED OUTPUT VOLTAGE OF 40 VOLTS.

2.4.3 REGULATION: 0.02% OR 100 MICROAMPERES MAXIMUM, WHICHEVER IS GREATER, FOR LINE OR LOAD VARIATIONS DOWN TO A SHORT CIRCUIT ACROSS THE OUTPUT TERMINALS.

2.4.4 RIPPLE: THE RIPPLE COMPONENT OF THE OUTPUT CURRENT IS LESS THAN .005% OR 20 MICROAMPERES, WHICHEVER IS GREATER.

2.4.5 SOURCE IMPEDANCE: 400,000 Ω APPROXIMATELY.

2.4.6 REMOTE PROGRAMMING RESISTANCE: OUTPUT CURRENT IS GIVEN BY THE RELATIONSHIP.

$$R = 2\,\frac{(525 - I)}{(I - 14)}$$

WHERE: I = DESIRED OUTPUT CURRENT IN MILLIAMPERES.
R = REMOTE PROGRAMMING RESISTANCE IN OHMS.

2.4.7 STABILITY: LESS THAN 0.1% OR 250 MICROAMPERES PER 24 HOURS AT CONSTANT AMBIENT TEMPERATURE WITH FIXED LOAD AND FIXED LOW TEMPERATURE COEFFICIENT EXTERNAL PROGRAMMING RESISTOR.

2.4.8 TEMPERATURE COEFFICIENT: DC OUTPUT CURRENT CHANGE LESS THAN .08% PER °C CHANGE IN AMBIENT.

2.5 OUTPUT TERMINALS:

2.5.1 FRONT PANEL: THREE INSULATED TYPE BINDING POSTS FOR POSITIVE AND NEGATIVE OUTPUT TERMINALS AND CHASSIS GROUND ARE PROVIDED.

2.5.2 REAR ACCESS: TWO SCREW TERMINALS ON A PHENOLIC STRIP AT THE REAR OF THE CABINET, PROVIDE ACCESS TO THE DC OUTPUT.

2.6 OUTPUT POLARITY: THE POSITIVE OR NEGATIVE OUTPUT TERMINAL MAY BE GROUNDED OR BOTH LEFT FLOATING IF DESIRED. THE MAXIMUM POTENTIAL BETWEEN OUTPUT TERMINALS AND GROUND SHOULD BE LIMITED TO 300 VOLTS DC MAXIMUM. THE RIPPLE CONTENT OF THE CONSTANT CURRENT OUTPUT MAY BE AFFECTED SOMEWHAT BY THE TYPE OR LOCATION OF LOAD CIRCUIT GROUNDING DUE TO THE EFFECTIVE HIGH SOURCE IMPEDANCE OF THIS MODE OF OPERATION.

2.7 METERING: A SINGEL METER WITH DUAL SCALES PERMITS MONITORING OF EITHER OUTPUT VOLTAGE OR CURRENT.

2.8 CIRCUIT PROTECTION: THE AC LINE AND DC LOAD CIRCUITS ARE SEPARATELY FUSED. THE MAXIMUM OUTPUT CURRENT OF THE SUPPLY IS ELECTRONICALLY LIMITED TO APPROXIMATELY 520 MILLIAMPERES AND THE DC FUSE WILL BLOW ONLY IF A CONTINUED LOAD IN EXCESS OF 500 MILLIAMPERES IS APPLIED OR IN THE EVENT OF INTERNAL CIRCUIT FAILURE.

3. MECHANICAL SPECIFICATIONS:

3.1 DIMENSIONS: 5 3/4" WIDE x 8 5/8" HIGH x 11 3/4" DEEP.

3.2 FINISH: THE PANEL IS FINISHED IN BRUSHED, ANODIZED, NATURAL ALUMINUM WITH ETCHED BLACK LETTERING. THE CABINET IS FINISHED IN A MUNSEL 4.5 GREY WRINKLE ENAMEL.

3.3 WEIGHT: 11.5 LBS.

4. OPERATION:

4.1 INSTALLATION: NO PRELIMINARY INSPECTION OR PROCESSING IS REQUIRED. THE POWER SUPPLY IS READY FOR OPERATION AS SHIPPED FROM THE FACTORY.

4.2 CONSTANT VOLTAGE OPERATION:

4.2.1 TURN LARGE CONCENTRIC CONTROL MARKED "CURRENT" TO EXTREME CLOCKWISE POSITION.

4.2.2 TURN LARGE CONCENTRIC CONTROL MARKED "VOLTAGE" TO EXTREME COUNTER CLOCKWISE POSITION.

4.2.3 MAKE SURE "AC" TOGGLE SWITCH IS IN THE OFF POSITION. CONNECT AC POWER CORD INTO CONVENIENT SOURCE OF 115 VAC, 55-440~.

4.2.4 THROW "AC" TOGGLE SWITCH ON. THE RED NEON PILOT INDICATOR SHOULD BE ILLUMINATED. IF IT IS NOT, CHECK AC LINE POWER AND THE 3/4 A PANEL LINE FUSE.

4.2.5 THROW "MA-V" METER FUNCTION SWITCH TO "V" AND SET THE "VOLTAGE" CONTROL TO THE DESIRED OUTPUT VOLTAGE. THE SMALL CONCENTRIC KNOB ON THIS CONTROL IS A FINE ADJUSTMENT WITH A RANGE OF APPROXIMATELY 1 VOLT AND PERMITS SETTING OF THE OUTPUT VOLTAGE WITH A RESOLUTION OF 5 MILLIVOLTS.

4.2.6 CURRENT LIMITING: IF IT IS DESIRED TO LIMIT THE MAXIMUM OUTPUT CURRENT OF THE SUPPLY, THROW THE METER FUNCTION SWITCH TO "MA", HOLD THE PUSHBUTTON MARKED "SET CONSTANT CURRENT" DEPRESSED AND ADJUST THE OUTPUT CURRENT TO THE DESIRED VALUE AS INDICATED ON THE METER BY MEANS OF THE LARGE CONCENTRIC "CURRENT" KNOB. IF THE DESIRED CURRENT IS LESS THAN 100 MILLIAMPERES, SET THE LARGE "CURRENT" KNOB TO ITS EXTREME COUNTER-CLOCKWISE POSITION ("SET FOR LOW RANGE" INDEX LINE.) THIS AUTOMATICALLY CONNECTS THE LOW RANGE CURRENT CONTROL INTO THE CIRCUIT AND PERMITS ADJUSTMENT DOWN TO 25 MILLIAMPERES BY MEANS OF THE SMALL CONCENTRIC "CURRENT" KNOB. RELEASE THE PUSHBUTTON TO RESTORE NORMAL OPERATION.

4.2.7 TURN THE "AC" TOGGLE SWITCH OFF AS A SAFELY PRECAUTION AND CONNECT THE EXTERNAL LOAD TO THE FRONT PANEL BINDING POSTS OR THE REAR ACCESS SCREW TERMINALS MARKED DC+ AND DC-. A JUMPER MAY BE CONNECTED FROM EITHER OUTPUT TERMINAL TO THE "G" OR CHASSIS TERMINAL ON THE FRONT PANEL OR THE SUPPLY MAY BE LEFT FLOATING, IF DESIRED.

4.3 REMOTE VOLTAGE PROGRAMMING: WHEN OPERATING THE POWER SUPPLY AS A CONSTANT VOLTAGE SOURCE, THE OUTPUT VOLTAGE CAN BE CONTROLLED FROM A REMOTE POINT (PROGRAMMED) WITH AN EXTERNAL FIXED OR VARIABLE RESISTOR. FOR PROGRAMMABLE OPERATION:

4.3.1 TURN "AC" TOGGLE SWITCH OFF.

4.3.2 REMOVE WIRE JUMPER BETWEEN SCREW TERMINALS "RV1" AND "RV2" ON THE REAR ACCESS TERMINAL STRIP.

4.3.3 CONNECT THE EXTERNAL PROGRAMMING RESISTOR BETWEEN TERMINAL "RV1" AND THE"DC+" TERMINAL. THE OUTPUT VOLTAGE IS PROPORTIONAL TO THIS RESISTOR BY A FACTOR OF 100 Ω PER VOLT OF OUTPUT. THIS VALUE IS APPROXIMATE AND THE REMOTE RESISTOR MAY HAVE TO BE TRIMMED SLIGHTLY TO PRODUCE THE EXACT OUTPUT VOLTAGE REQUIRED. A CONSTANT CURRENT OF 10 MILLIAMPERES WILL FLOW THROUGH THIS RESISTOR AND ITS WATTAGE RATING SHOULD BE CHOSEN TO MINIMIZE DRIFT DUE TO HEATING EFFECTS.

4.4 EXTENDING THE OUTPUT VOLTAGE RANGE: THE USEFUL OUTPUT VOLTAGE RANGE OF THE SUPPLY MAY BE EXTENDED UP TO 70 VOLTS (AT REDUCED OUTPUT CURRENT) BY REMOVING THE WIRE JUMPER BETWEEN SCREW TERMINALS "RV1" AND "RV2" ON THE REAR ACCESS TERMINAL STRIP.

REPLACE THIS JUMPER WITH A RESISTOR WHOSE VALUE IS 100 Ω FOR EVERY VOLT ABOVE THE MAXIMUM OUTPUT VOLTAGE (41 VOLTS) DESIRED. FOR EXAMPLE A 3,000 Ω RESISTOR WILL EXTEND THE RANGE OF THE PANEL "VOLTAGE" CONTROL TO 30 - 70 VOLTS. AT 70 VOLTS THE MAXIMUM OUTPUT CURRENT SHOULD BE LIMITED TO 50 MILLIAMPERES TO INSURE OPERATION OF THE VOLTAGE REGULATOR OVER THE INPUT AC LINE VOLTAGE RANGE. AT LOWER OUTPUT VOLTAGES THIS CURRENT MAY BE INCREASED PROPORTIONATELY. THE WATTAGE RATING OF THIS RESISTOR SHOULD BE CHOSEN AS PER PARAGRAPH 4.3.3. ABOVE 50 VOLTS THE PANEL METER WILL READ OFF SCALE AND AN EXTERNAL METER MUST BE EMPLOYED TO SET THE OUTPUT VOLTAGE. THE METER WILL NOT BE DAMAGED IF OPERATED CONTINUOUSLY IN THIS CONDITION.

4.5 CONSTANT CURRENT OPERATION:

4.5.1 TURN LARGE CONCENTRIC KNOB MARKED "VOLTAGE" TO EXTREME CLOCKWISE POSITION.

4.5.2 TURN LARGE AND SMALL CONCENTRIC CONTROL KNOBS MARKED "CURRENT" TO EXTREME COUNTER-CLOCKWISE POSITION.

4.5.3 THROW "MA-V" METER FUNCTION SWITCH TO "MA". HOLD THE PUSHBUTTON MARKED "SET CONSTANT CURRENT" DEPRESSED AND ADJUST THE OUTPUT CURRENT TO THE DESIRED VALUE AS INDICATED ON THE METER BY MEANS OF THE SMALL OR LARGE CONCENTRIC "CURRENT" CONTROL KNOB. NOTE THAT THE SMALL CONTROL KNOB DOES NOT FUNCTION UNLESS THE LARGE CONTROL KNOB IS SET TO ITS EXTREME COUNTER-CLOCKWISE POSITION.

4.5.4 RELEASE THE "SET CONSTANT CURRENT" PUSHBUTTON AND CONNECT THE EXTERNAL LOAD TO THE SUPPLY TO EITHER THE FRONT PANEL BINDING POSTS OR TO THE REAR ACCESS SCREW TERMINALS AS DESIRED. A JUMPER MAY BE CONNECTED FROM EITHER OUTPUT TERMINAL TO THE "G" OR CHASSIS TERMINAL (ON THE FRONT PANEL), OR THE SUPPLY MAY BE LEFT FLOATING. SINCE THE NATURE OF THE CONSTANT CURRENT SUPPLY IS THAT OF A HIGH IMPEDANCE SOURCE, THE ELECTROSTATIC (CAPACITIVE) RELATIONSHIP OF THE CONSTANT CURRENT SOURCE OR THE LOAD TO EXTERNAL GROUNDS AND/OR THE AC LINE MAY AFFECT THE RIPPLE COMPONENT OF THE CURRENT OUTPUT. REVERSING THE AC LINE CORD TO THE SUPPLY, EXPERIMENTALLY SELECTING AN OPTIMUM GROUNDING POINT AT THE LOAD, OR OPERATING THE CONSTANT CURRENT OUTPUT FLOATING, CAN REDUCE THIS RIPPLE COMPONENT TO A MINIMUM.

4.5.5 VOLTAGE LIMITING: UNDER CERTAIN OPERATING CONDITIONS IT MAY BE DESIRABLE TO LIMIT THE MAXIMUM VOLTAGE OUTPUT OR COMPLIANCE OF THE SUPPLY WHEN OPERATED AS A CONSTANT CURRENT DEVICE. WITH THE "VOLTAGE" CONTROL SET TO ITS MAXIMUM CLOCKWISE POSITION THIS OUTPUT IS APPROXIMATELY 42-45 VOLTS. TO LIMIT THIS VOLTAGE, REMOVE THE CONSTANT CURRENT LOAD FROM THE SUPPLY AND ADJUST THE "VOLTAGE" CONTROL TO THE DESIRED MAXIMUM COMPLIANCE AS INDICATED ON THE PANEL METER WITH THE METER FUNCTION SWITCH IN THE "V" POSITION.

4.6 Remote Current Programming: When operating the power supply as a constant current source, the output current can be controlled from a remote point (programmed) with an external fixed or variable resistor. For remote programmable operation:

4.6.1 Turn "AC" toggle switch off.

4.6.2 Remove wire jumper between screw terminals "RC" and "DC-"

4.6.3 Turn large "CURRENT" control knob to its extreme clockwise position. (This control is internally connected in series with the external programming resistor and will affect the current output if not left in this position.)

4.6.4 Connect the external programming resistor between terminal "RC" and the "DC-" terminal. The output current is determined by the relationship.

$$R = 2\left(\frac{525 - I}{I - 14}\right)$$

Where: I = desired output current in milliamperes.
R = remote programming resistance in ohms.

4.7 Electronic Crossover From Voltage to Current or Vice Versa:

The Model 4005 power supply may be operated to switch electronically from a constant voltage source to a constant current source or vice versa at any predetermined voltage or current in its operating range. The power supply will function in this manner when set up as per the following procedure. This procedure is valid regardless of the direction of crossover (constant voltage to current or current to voltage.)

4.7.1 Remove load from power supply.

4.7.2 Turn "CURRENT" controls to extreme clockwise position.

4.7.3 Set "VOLTAGE" control to desired voltage cross-over point.

4.7.4 Depress "SET CONSTANT CURRENT" pushbutton and adjust "CURRENT" controls to desired current cross-over point.

4.7.5 Reconnect load and operate supply. For all load resistance values where the product of the load resistance and the preset constant current value (par. 4.7.4) is less than the preset voltage value (par. 4.7.3), the power supply will function as a constant voltage source. For all conditions where the product of the load resistance and the preset current value is greater than the preset voltage. The supply will function as a constant current source. The power supply will automatically switch back and forth to either mode of operation depending upon the load resistance

VALUE. THE REGULATION OF THE POWER SUPPLY IN THE CROSSOVER REGION IS SUCH THAT THE OUTPUT VOLTAGE WILL NOT CHANGE MORE THAN 0.1% OR 40 MILLIVOLTS FROM ITS PRESET VALUE (PAR. 4.7.3), OR THE OUTPUT CURRENT MORE THAN 0.1% OR 500 MICROAMPERES FROM ITS PRESET VALUE (PAR. 4.7.4) BEFORE THE POWER SUPPLY HAS SWITCHED INTO THE NEW MODE OF OPERATION. IN THE REGION BEYOND THE CROSSOVER AREA THE VOLTAGE OR CURRENT REGULATION WILL BE WITHIN THE RATED SPECIFICATIONS FOR THAT MODE OF OPERATION.

4.8 SERIES OPERATION:

4.8.1 CONSTANT VOLTAGE: AS MANY AS EIGHT MODEL 4005 UNITS MAY BE OPERATED IN SERIES TO PROVIDE A MAXIMUM OUTPUT VOLTAGE OF 320 VOLTS. IN THIS MODE OF OPERATION THE "CURRENT" CONTROLS ON ALL SERIES CONNECTED UNITS SHOULD BE TURNED TO THEIR MAXIMUM CLOCKWISE POSITION. THE GROUND TERMINAL ON ALL UNITS MAY BE LEFT FLOATING OR CONNECTED TOGETHER AND TIED EITHER TO THE MOST NEGATIVE OR POSITIVE OUTPUT TERMINAL, IF DESIRED.

4.8.2 CURRENT LIMITING OR CONSTANT CURRENT: THE MODEL 4005 POWER SUPPLY MAY BE OPERATED AS A CONSTANT VOLTAGE/CURRENT LIMITED DEVICE OR A CONSTANT CURRENT SOURCE WHEN CONNECTED IN SERIES. HOWEVER, CERTAIN LIMITATIONS EXIST WHICH MUST BE UNDERSTOOD TO OPERATE THE POWER SUPPLIES SUCCESSFULLY. THESE LIMITATIONS ARE BASED ON THE FACT THAT EACH POWER SUPPLY CONNECTED IN SERIES OPERATES INDEPENDENTLY AS FAR AS ELECTRONIC CROSSOVER FROM VOLTAGE REGULATION TO CURRENT REGULATION IS CONCERNED. A TYPICAL EXAMPLE IS THAT OF TWO SUPPLIES CONNECTED IN SERIES WITH BOTH "VOLTAGE" CONTROLS SET TO 40 VOLTS AND BOTH "CURRENT" CONTROLS TO 100 MILLIAMPERES. WITH RESISTIVE LOADS IN EXCESS OF 800 Ω THE POWER SUPPLY WILL FUNCTION AS A CONVENTIONAL 80 VOLT REGULATED SOURCE. AS THE RESISTIVE LOAD FALLS BELOW 800 Ω, ONLY ONE OF THE SUPPLIES WILL AUTOMATICALLY CROSS OVER INTO CONSTANT CURRENT MODE. THIS IS DUE TO THE FACT THAT IT IS PRACTICALLY IMPOSSIBLE TO SET BOTH CURRENT CONTROLS TO THE IDENTICAL CURRENT VALUE. THUS, THE POWER SUPPLY WHICH FIRST SWITCHES INTO THE CURRENT MODE WILL PERFORM THE FUNCTION OF PROVIDING CONSTANT CURRENT OR CURRENT LIMITING, THE OTHER SUPPLY CONTINUING AS A CONSTANT VOLTAGE SOURCE (THIS WILL NOT AFFECT REGULATION OR RIPPLE). AS THE LOAD RESISTANCE CONTINUES TO DECREASE, THE CONSTANT CURRENT UNIT WILL MAINTAIN STABLE OUTPUT CURRENT WITH ITS OUTPUT VOLTAGE DECREASING AS THE LOAD RESISTANCE DECREASES, UNTIL ZERO OUTPUT VOLTAGE IS REACHED. WITH A FURTHER DECREASE IN RESISTANCE THE VOLTAGE ACROSS THIS SUPPLY REVERSES AND IT CEASES TO SUPPLY CURRENT TO THE LOAD. INSTEAD, AN INTERNALLY CONNECTED SILICON POWER DIODE (CR15) SHUNTED ACROSS THE OUTPUT TERMINALS IN REVERSE POLARITY TO THE NORMAL OUTPUT VOLTAGE AND THUS NON-CONDUCTIVE, BECOMES CONDUCTIVE AND CARRIES THE LOAD CURRENT AROUND THE

INOPERATIVE UNIT. AT THIS POINT THE SECOND SUPPLY WILL CROSS OVER INTO ITS CONSTANT CURRENT MODE AND LIMIT OR MAINTAIN THE OUTPUT CURRENT AT THE SETTING OF ITS OWN "CURRENT" CONTROL. THE SETTING OF THIS CONTROL MAY NOT BE THE SAME (MAY BE DELIBERATELY SET TO ANOTHER VALUE) AND A DISCRETE SHIFT TO A NEW CURRENT LEVEL MAY BE OBSERVED.

SIMILARLY, A NUMBER OF SUPPLIES CONNECTED IN SERIES WILL CROSS OVER AUTOMATICALLY TO CONSTANT CURRENT OPERATION IN SEQUENCE AND IN THE ORDER OF THE LOWEST PRESET CURRENT VALUE OF ANY UNIT, FIRST. THE ACCURACY OF THE CURRENT LIMITING OR CONSTANT CURRENT VALUE OF THE SERIES CONNECTED UNITS WILL DEPEND UPON THE ACCURACY OF CURRENT SETTING OF THE CONTROL ON EACH SUPPLY. HOWEVER, SINCE THE RESOLUTION OF THE "CURRENT" CONTROL IS IN THE ORDER OF 4%, THE REGULATION OF THE CONSTANT CURRENT SOURCE CANNOT BE CONSIDERED TO BE BETTER THAN 4% WITH A VOLTAGE COMPLIANCE FROM ZERO TO THE MAXIMUM OUTPUT OF THE SERIES CONNECTED UNITS.

4.9 PARALLEL OPERATION: OPERATION OF MORE THAN TWO UNITS IN PARALLEL IS NOT RECOMMENDED. TWO UNITS MAY BE OPERATED IN PARALLEL WITH A MAXIMUM RATED CURRENT OF ONE AMPERE AS FOLLOWS:

4.9.1 WITH BOTH POWER SUPPLIES TURNED OFF, CONNECT THEIR OUTPUT TERMINALS IN PARALLEL WITH HEAVY GAUGE WIRE TO MINIMIZE VOLTAGE DROP. DO NOT CONNECT THE LOAD.

4.9.2 TURN THE LARGE CONCENTRIC "VOLTAGE" AND "CURRENT" CONTROLS ON BOTH UNITS TO THEIR EXTREME CLOCKWISE POSITION.

4.9.3 TURN ON ONE POWER SUPPLY AND SET ITS "VOLTAGE" CONTROL TO THE DESIRED OUTPUT VOLTAGE.

4.9.4 DEPRESS THE "SET CONSTANT CURRENT" PUSHBUTTON AND ADJUST THE LARGE CONCENTRIC "CURRENT" CONTROL TO 500 MILLIAMPERES. LEAVE THE PANEL METER SET TO READ MILLIAMPERES.

4.9.5 TURN THE SECOND SUPPLY ON AND TURN THE LARGE CONCENTRIC "VOLTAGE" CONTROL COUNTER-CLOCKWISE VERY SLOWLY OBSERVING THE METER WITH THE FUNCTION SWITCH IN THE "MA" POSITION. THE METER SHOULD READ A CURRENT OUTPUT OF APPROXIMATELY 30 MILLIAMPERES. THIS VALUE SHOULD FALL SLOWLY TO APPROXIMATELY 20 MILLIAMPERES AS THE "VOLTAGE" CONTROL IS TURNED. DURING THIS PERIOD THE CURRENT READING ON THE FIRST SUPPLY WILL BE NEGATIVE OR REVERSED. THIS CONDITION IS NORMAL. AT A CERTAIN POINT THE METER READINGS SHOULD REVERSE ABRUPTLY, THE POSITIVE READING BECOMING NEGATIVE AND VICE VERSA. THE POWER SUPPLY SHOUD BE CAREFULLY ADJUSTED TO THIS CROSSOVER POINT. IDEALLY THE "VOLTAGE" CONTROLS SHOULD BE MANIPULATED SO THAT A TURN OF A DEGREE OR SO OF THE "FINE" VOLTAGE CONTROL SHOULD PRODUCE THE CURRENT REVERSAL. THE "VOLTAGE" CONTROLS SHOULD BE LEFT AT THIS ADJUSTMENT. IF THE POWER SUPPLIES ARE OPERATED AT THEIR MAXIMUM OUTPUT OF 40 VOLTS IT MAY BE NECESSARY TO MANI-

PULATE THE "VOLTAGE" CONTROLS OF BOTH SUPPLIES TO REACH THE CROSSOVER POINT.

4.9.6 CONNECT THE LOAD TO THE SUPPLIES AND OPERATE. NOTE THAT THE LOAD CURRENT WILL NOT DIVIDE EQUALLY, BUT THAT ONE SUPPLY WILL FURNISH ALMOST ALL OF THE CURRENT UP TO 500 MILLI-AMPERES. AT THIS POINT THIS POWER SUPPLY WILL SWITCH INTO ITS CONSTANT CURRENT MODE WITH THE OTHER UNIT PROVIDING THE VOLTAGE REGULATION AND THE ADDITIONAL CURRENT UP TO A TOTAL OF ONE AMPHERE.

5. THEORY OF OPERATION:

THE MODEL 4005 TRANSISTORIZED POWER SUPPLY CONSISTS OF AN UNREGULATED SOURCE COMPRISING A TRANSFORMER, A FULL WAVE RECTIFIER, A CAPACITOR INPUT FILTER AND A REGULATOR OF THE CONVENTIONAL "SERIES" TYPE. THE OPERATION OF THIS TYPE OF REGULATOR HAS BEEN AMPLY DESCRIBED IN THE LITERATURE AND CONSISTS BASICALLY OF AN ELECTRONICALLY VARIABLE RESISTANCE (TRANSISTOR OR VACUUM TUBE) INTERPOSED BETWEEN AN UNREGULATED SOURCE AND A LOAD. THE VALUE OF RESISTANCE IS CONTROLLED BY AN AMPLIFIER WHOSE INPUT COMPARES THE OUTPUT VOLTAGE OF THE SUPPLY WITH A REFERENCE, AMPLIFIES THE ERROR SIGNAL BETWEEN THE TWO, AND APPLIES THE AMPLIFIED SIGNAL TO THE ELECTRONIC SERIES RESISTANCE TO ADJUST THIS RESISTANCE TO MAINTAIN CONSTANT OUTPUT VOLTAGE OR CURRENT. THE MODEL 4005, AS WELL, UTILIZES A SERIES TRANSISTOR PRECEDED BY AN AMPLIFIER/DRIVER STAGE FOR THE SERIES CONTROL FUNCTION (Q3,Q4). HOWEVER, THIS POWER SUPPLY DIFFERS FROM THE CONVENTIONAL SERIES REGULATOR IN THAT TWO, 2-STAGE CONTROL AMPLIFIERS ARE EMPLOYED, ONE, SENSING THE OUTPUT CURRENT FLOWING INTO THE LOAD, THE OTHER SENSING THE OUTPUT VOLTAGE.*

THE CURRENT SENSING AMPLIFIER COMPARES THE VOLTAGE DROP ACROSS A RESISTOR IN SERIES WITH THE OUTPUT OF THE SUPPLY AND A VOLTAGE REFERENCE. THE AMPLIFIER OPERATES TO MAINTAIN THE VOLTAGE DROP ACROSS THIS RESISTANCE EQUAL TO THAT OF THE REFERENCE VOLTAGE WITHIN THE REGULATION LIMITS OF THE EQUIPMENT. SINCE THIS RESISTANCE IS ADJUSTABLE FOR A REQUIRED CURRENT OUTPUT, THE CURRENT OUTPUT OF THE SUPPLY WILL BE HELD TO A CONSTANT VALUE DETERMINED BY THE VALUE OF THIS RESISTANCE, AS LONG AS THE CURRENT AMPLIFIER IS OPERATIVE.

SIMILARLY, A VOLTAGE DIVIDER ACROSS THE OUTPUT TERMINALS OF THE SUPPLY COMPARES A PORTION OF THE OUTPUT VOLTAGE TO A VOLTAGE REFERENCE, AMPLIFIES THE DIFFERENCE AND APPLIES THE AMPLIFIED SIGNAL TO THE SERIES TRANSISTOR TO VARY ITS EFFECTIVE SERIES RESISTANCE TO MAINTAIN THE OUTPUT VOLTAGE CONSTANT AS LONG AS THIS AMPLIFIER IS OPERATIVE.

THE CONSTANT VOLTAGE AMPLIFIER CONSISTS OF Q7 AND Q8. THE OUTPUT VOLTAGE SENSING DIVIDER CONSISTS OF R39, THE "VOLTAGE" ADJUSTING PANEL POTENTIOMETER, R38, R25 AND R26. THE VOLTAGE REFERENCE CONSISTS OF THE TOTAL OUTPUT (10.5 VOLTS) OF AN INTERNAL VOLTAGE REGULATED AUXILIARY POWER SUPPLY PROVIDED FOR THIS FUNCTION.

THE CONSTANT CURRENT AMPLIFIER CONSISTS OF Q5 AND Q6. THE VOLTAGE REFERENCE FOR THIS AMPLIFIER IS OBTAINED FROM A DIVIDER, R19, R18, R13 CONNECTED IN SERIES ACROSS THE REGULATED AUXILIARY SUPPLY. THE VOLTAGE ACROSS R13 IS COMPARED WITH THE VOLTAGE DROP ACROSS THE CURRENT SENSING NETWORK IN SERIES WITH THE SUPPLY OUTPUT COMPOSED OF R22 AND THE FRONT PANEL "CURRENT" CONTROL POTENTIOMETER R 12.

AUTOMATIC DETERMINATION OF WHICH AMPLIFIER (VOLTAGE OR CURRENT) CONTROLS THE SERIES TRANSISTOR AND THEREFORE THE VOLTAGE OR CURRENT OUTPUT OF THE SUPPLY IS ACHIEVED BY THE SETTING OF THE PANEL "VOLTAGE" AND "CURRENT" POTENTIOMETERS IN THE FOLLOWING MANNER: IF THE OUTPUT CURRENT IN THE LOAD IS LOWER THAN THE DESIRED CONSTANT CURRENT LEVEL DETERMINED BY THE SETTING OF THE "CURRENT" POTENTIOMETER R12A AND R12B THE VOLTAGE DROP ACROSS THIS POTENTIOMETER AND R22 WILL BE LOWER THAN THE REFERENCE VOLTAGE PROVIDED BY R13. THE BASE-EMITTER POTENTIAL ON Q6 WILL THEREFORE BE REVERSED AND Q6 WILL BE CUT OFF. SIMILARLY Q5 WILL BE CUT OFF AND THUS WILL HAVE NO EFFECT ON THE AMPLIFIER/DRIVER Q4 OR THE SERIES TRANSISTOR Q3. HOWEVER, Q7 AND Q8 THE VOLTAGE CONTROL AMPLIFIER WILL BE OPERATIVE AND CONTROL THE SERIES REGULATOR Q3 TO MAINTAIN A CONSTANT VOLTAGE OUTPUT.

*PATS. APPLIED FOR.

AS SOON AS THE OUTPUT CURRENT INCREASES TO A VALUE SUCH THAT THE DROP ACROSS R12A, RR12B AND R22 EQUALS OR EXCEEDS THE VOLTAGE ACROSS R13, Q6 AUTOMATICALLY MOVES INTO ITS OPERATING REGION AND Q5 WILL BEGIN TO DRAW COLLECTOR CURRENT. THIS COLLECTOR CURRENT WILL AFFECT THE BASE CURRENT OF Q4 AND THE EFFECTIVE RESISTANCE OF Q3 TO BEGIN TO LIMIT THE OUTPUT CURRENT TO THE PREDETERMINED CURRENT LEVEL SET BY THE "CURRENT" CONTROL. THIS RESULTS IN A DROP IN OURPUT VOLTAGE. HOWEVER SINCE THE VOLTAGE CONTROL AMPLIFIER IS STILL OPERATIVE IT WILL COMPENSATE TO MAINTAIN CONSTANT OUTPUT VOLTAGE BY ADJUSTING THE BASE CURRENT OF Q4 TO CONTINUE TO MAINTAIN CONSTANT OUTPUT VOLTAGE. THE VOLTAGE CONTROL AMPLIFIER ACCOMPLISHES THIS FUNCTION BY REDUCING ITS OUTPUT CURRENT TO MAINTAIN THE ORIGINAL BIAS LEVEL ON Q4 WHEN THE CURRENT AMPLIFIER WAS CUT OFF. AS THE OUTPUT CURRENT CONTINUES TO RISE THIS PROCESS CONTINUES UNTIL Q7 AND Q8 ARE COMPLETELY CUT OFF AND CEASE TO HAVE ANY FURTHER EFFECT ON THE OUTPUT OF THE SUPPLY. THE RREGULATION FUNCTION WILL THEN BE TAKEN OVER COMPLETELY BY THE CURRENT AMPLIFIER Q5 AND Q6. Q5 AND Q6 WILL CONTINUE TO FUNCTION CONTROLLING THE CURRENT OUTPUT OF THE POWER SUPPLY UP TO THE MAXIMUM LIMIT OF THE EQUIPMENT (A SHORT CIRCUIT ACROSS THE OUTPUT TERMINALS). CONVERSELY, AS THE OUTPUT CURRENT FALLS THE PROCESS REVERSES UNTIL Q5 AND Q5 RETURN TO CUTOFF, Q7 AND Q8 BECOME OPERATIVE AND THE POWER SUPPLY THEN REVERTS TO ITS ORIGINAL CONSTANT VOLTAGE OPERATION.

SINCE THE REGULATOR IS CONSTANTLY UNDER THE CONTROL OF EITHER THE VOLTAGE OR CURRENT AMPLIFIERS AND IS ACTUALLY CONTROLLED IN THE VOLTAGE/CURRENT CROSSOVER REGION BY BOTH AMPLIFIERS, NO LOSS OF REGULATION OCCURS IN THE CROSSOVER REGION AND THE POWER SUPPLY SWITCHES SMOOTHLY AND AUTOMATICALLY FROM ONE MODE TO ANOTHER, DEPENDING UPON THE PREDETERMINED CURRENT AND VOLTAGE LEVELS SET BY THE PANEL POTENTIOMETERS AND THE REQUIREMENTS OF THE EXTERNAL LOAD.

THE VOLTAGE REGULATED INTERNAL AUXILIARY SUPPLY UTILIZES AN ADDITIONAL WINDING ON THE POWER TRANSFORMER, A FULL WAVE RECTIFIER, A CAPACITOR INPUT FILTER AND A THREE STAGE "SERIES" TYPE VOLTAGE REGULATOR COMPRISING TRANSISTORS Q9, Q10 AND Q11. THE OUTPUT VOLTAGE OF THIS AUXILIARY SUPPLY IS UNUSUALLY STABLE AS A RESULT OF THE UTILIZATION OF A ZERO TEMPERATURE COEFFICIENT ZENER DIODE AS A VOLTAGE REFERENCE AND ANOTHER ZERO TEMPERATURE COEFFICIENT ZENER DIODE, AS A NON-LINEAR VOLTAGE ERROR SENSING RESISTANCE. THE VOLTAGE REGULATION OF THIS TYPE OF SYSTEM IS AUTOMATICALLY IMPROVED BY A FACTOR DETERMINED BY THE RATIO OF THE EFFECTIVE VALUE OF THE D-C RESISTANCE OF THE ZENER DIODE EMPLOYED AS THE NON-LINEAR SENSING ELEMENT AND ITS DYNAMIC IMPEDANCE.

THE MODEL 4005 ALSO INCORPORATES THE PATENT APPLIED FOR "HEATRAN" POWER DISSIPATION SHIFT CIRCUITRY. THIS TECHNIQUE MONITORS THE VOLTAGE DROP IN THE SERIES TRANSISTOR AND OPERATES TO MAINTAIN THIS VOLTAGE BELOW A PRESET MAXIMUM VALUE AT ALL CONDITIONS OF LINE OR LOAD. THE CIRCUIT CONSISTS OF (Q2), A TRANSISTOR INSERTED IN SERIES BETWEEN THE UNREGULATED SOURCE AND THE SERIES TRANSISTOR (Q2). THIS TRANSISTOR IS NORMALLY HELD IN A "SATURATED" CONDITION (MINIMUM COLLECTOR-EMMITTER VOLTAGE) BY AN EXTERNAL BIAS SOURCE. THIS BIAS IS OBTAINED THROUGH R6 FROM THE AUXILIARY POWER SUPPLY. THE VOLTAGE DROP ACROSS THE SERIES TRANSISTOR IS COMPARED WITH A REFERENCE VOLTAGE. (IN THE MODEL 4005, THIS REFERENCE IS THE 10.5V REGULATED OUTPUT FROM THE AUXILIARY SUPPLY). AS LONG AS THE COLLECTOR-EMMITTER VOLTAGE DROP ACROSS Q3 IS BELOW THIS VALUE THIS

~~TRANSISTOR (Q2) REMAINS SATURATED AND PRACTICALLY ALL OF THE OUTPUT CURRENT FLOWS~~ THROUGH THIS TRANSISTOR. AS SOON AS THE VOLTAGE DROP ACROSS Q3 APPROACHES THE REFERENCE VOLTAGE, Q2 RAPIDLY COMES OUT OF SATURATION AND GOES TOWARD CUT-OFF. AN INCREASINGLY PROPORTIONATE AMOUNT OF THE OUTPUT CURRENT IS NOW DIVERTED THROUGH R5 THE VITREOUS ENAMEL POWER RESISTOR WHICH EXTENDS FROM THE POWER SUPPLY INTO A CAGE AT THE REAR OF THE CABINET. UNDER MAXIMUM INTERNAL DISSIPATION CONDITIONS IN THE REGULATOR SYSTEM Q2 IS CUT OFF, THE DROP ACROSS Q3 IS HELD TO APPROXIMATELY 10.5 VOLTS (A MAXIMUM DISSIPATION OF 5.25 WATTS). UNDER THESE CONDITIONS THE MAXIMUM DISSIPATION IN R5 IS APPROXIMATELY 30 WATTS. THUS, THE POWER SUPPLY POWER TRANSISTORS WITH THIS TECHNIQUE ARE DISSIPATING ONLY 1/6 OF THE NORMAL DISSIPATION WHICH WOULD OCCUR IN THESE DEVICES IN A CONVENTIONAL POWER SUPPLY. "HEATRAN" CONSEQUENTLY PERMITS A DESIGN INCORPORATING FEWER TRANSISTORS FOR A GIVEN POWER SUPPLY CAPACITY MORE COMPACT EQUIPMENT WITH INCREASED RELIABILITY AND SIMPLE PRACTICAL CONVECTION COOLING.

6 MAINTENANCE:

UNDER NORMAL CONDITIONS NO SPECIAL MAINTENANCE OF THE MODEL 4005 IS REQUIRED AND THE EQUIPMENT SHOULD PROVIDE TROUBLE-FREE SERVICE FOR MANY YEARS.

IN THE EVENT OF IMPROPER FUNCTIONING OF THE SUPPLY CERTAIN PRECAUTIONS MUST BE OBSERVED IN REPAIR AND MAINTENANCE OF TRANSISTORIZED HIGH GAIN, CLOSED LOOP D-C AMPLIFIERS TO AVOID THE POSSIBILITY OF CHAIN REACTION TRANSISTOR BURNOUTS. THE FOLLOWING NOTES SHOULD BE READ THOROUGHLY BEFORE PRECEEDING TO REPAIR THE POWER SUPPLY.

6.1 SCHEMATIC DIAGRAMS: TWO SCHEMATIC DIAGRAMS ARE INCLUDED IN THIS MANUAL. ONE GIVES COMPLETE VOLTAGE INFORMATION AND OPERATING POTENTIALS IN THE CIRCUIT WITH THE SUPPLY FUNCTIONING AS A CONSTANT VOLTAGE SOURCE. THE OTHER FURNISHES EQUIVALENT INFORMATION WITH THE SUPPLY OPERATING IN ITS CONSTANT CURRENT MODE.

6.2 COMPONENT LOCATION DIAGRAM: A DRAWING OF THE CONTROL AMPLIFIERS TERMINAL BOARD SHOWING TRANSISTOR AND COMPONENT LOCATION ON THE FRONT AND REAR SURFACES IS INCLUDED IN THIS MANUAL AND PROVIDES AN AID IN THE LOCATION OF COMPONENTS FOR VOLTAGE MEASUREMENT, ETC. WHEN MAINTAINING THE EQUIPMENT.

6.3 GENERAL MAINTENANCE: THE MOST RAPID METHOD OF ISOLATION OF CIRCUIT FAULTS IN THE POWER SUPPLY IS THAT OF VOLTAGE MEASUREMENTS AT THE TRANSISTORS, CAPACITORS AND TRANSFORMER OF THE SUPPLY. EMPLOYMENT OF THE TABLES ON THE SCHEMATIC DIAGRAMS AS PER PAR. 6.1 ABOVE SHOULD CONSTITUTE THE FIRST STEP IN THE SERVICING OF THE SUPPLY.

CAUTION: WHEN REMOVING ANY SEMICONDUCTOR COMPONENTS FOR TEST A HEAT SINK SHOULD BE EMPLOYED WHEN UNSOLDERING TO AVOID THERMAL DAMAGE. A LONG NOSED PLIERS BETWEEN THE SEMICONDUCTOR DEVICE AND THE SOLDER JUNCTION IS GENERALLY ADEQUATE.

DO NOT OPERATE THE POWER SUPPLY WITH ANY LEADS DISCONNECTED OR SEMICONDUCTOR DEVICES REMOVED FROM THE CIRCUIT. PROPER OPERATING POTENTIALS IN D-C AMPLIFIERS MAY CHANGE RADICALLY WHEN A COMPONENT IS REMOVED OR DISCONNECTED, RESULTING IN POSSIBLE CHAIN REACTION BURNOUTS OF TRANSISTORS, DIODES, ETC.

6.4 GENERAL SYMPTONS AND SUGGESTED PROCEDURES:

6.4.1 POWER SUPPLY DOES NOT GO ON: CHECK PANEL FUSES AND PRESENCE OF A-C LINE VOLTAGE ACROSS TERMINALS 1 AND 2 OF T1. IF A-C FUSE (F1 3/4 AMP.) BLOWS REPEATEDLY CHECK CR1, CR2, CR3, CR4 FOR SHORTS WITH AN OHMMETER, REVERSING THE METER LEADS. IF THE RESISTANCE READING IS THE SAME IN BOTH DIRECTIONS THE DIODE IS DEFECTIVE. CR1 AND CR2, OR CR3 AND CR4 SHOULD BE REPLACED AS PAIR SINCE A SHORT CIRCUIT IN EITHER WILL PRODUCE HEAVY SURGE CURRENTS IN THE OTHER, POSSIBLY PRODUCING JUNCTION DAMAGE.

6.4.2 No D-C Output Voltage: Check ~~for proper potentials across C1~~ and C6. If current meter ~~reads~~ full scale with current control turned full clockwise with no output voltage, check safety diode CR15 for short employing ohmmeter methods as per Par. 6.4.1. Transistorized power supplies are extremely sensitive to potentials applied to their output terminals in excess to the adjusted output voltage or in reverse polarity to the output voltage, regardless of whether the power supply is turned on or not. The output electrolytic capacitor can be readily damaged by reverse potentials (C8) and the voltage sensing transistors may see excessive or reverse potentials applied to their base-emmiter junctions which may result in permanent damage. A safety diode is employed in the Model 4005 to protect the equipment against reverse potentials. This diode is normally connected in polarity opposition to the D-C output voltage and is therefore non-conductive. In the event of reverse polarity potentials applied to the output terminals this diode conducts to limit the reverse potential to approximately 1 volt. The capacity of this diode is 750 milliamperes and in the event of reverse current flow in excess of this value the diode may weld resulting in a permanent short circuit. This prevents further damage to the power supply and normal operation can be restored by replacement of the device.

6.4.3 Failure to Regulate in Either Voltage or Current Mode: Check for proper potentials on amplifier transistors, voltage references, etc., as per schematic diagrams. If any voltage appears to be incorrect turn power supply off and make a rapid check for defective transistors as follows: This check can be made without removing the device from the circuit with an ohmmeter set to its low resistance scale.(Rx1). Measure the forward/reverse resistance ratio of the collector-base junction, the base-emmiter junction and the collector-emitter resistance by reversing the meter leads. A resistance ratio of less-than 5 to 1 will indicate a defective unit. If a transistor appears to be defective remove carefully and check on a good transistor tester. This same technique may be applied to rectifiers and zener diodes as well.

6.4.4 Poor Regulation, High Ripple Output: No specific check can be suggested since failure to regulate within specifications may be caused by any component in the system. A point-to-point voltage and resistance check should be made. Capacitors should be checked for "opens" or excessive leakage in the case of electrolytic units. Stage gain measurements may be made by changing the output load current and noting the change in base current in each amplifier stage. Low resistance milliammeters and microammeters should be employed to avoid upsetting the regulator. The open loop current gain of the regulator system should not be less than 10^6

FROM THE BASE CURRENT OF THE INPUT COMPARATOR TO THE COLLECTOR CURRENT OF Q3. IT MAY BE DESIRABLE TO OPEN THE COLLECTOR LEAD OF Q5 WHEN CHECKING THE VOLTAGE REGULATOR OR Q8 WHEN CHECKING THE CURRENT REGULATOR TO AVOID INTERACTION.

6.5 RECALIBRATION: IF ANY COMPONENTS HAVE BEEN REPLACED IT MAY BE NECESSARY TO READJUST AND RECALIBRATE THE SUPPLY.

6.5.1 CURRENT RANGE ADJ. (R19): TO RESET THE D-C OUTPUT CURRENT RANGE, TURN "VOLTAGE" CONTROLS AND "CURRENT" CONTROLS TO FULL CLOCKWISE POSITION. CONNECT MILLIAMMETER ACROSS D-C OUTPUT TERMINALS OF THE POWER SUPPLY. TURN ON SUPPLY AND-ADJUST SCREW SLOT TRIMMER R19 SO THAT MILLIAMMETER READS 520 MILLIAMPERES. THEN TURN DOWN LARGE "CURRENT" CONTROL KNOB TO "SET FOR LOW RANGE" POSITION (MAX. CCW.). CHECK MILLIAMMETER TO MAKE SURE THAT METER READS SLIGHTLY LESS THAN 100 MILLIAMPERES. A SLIGHT READJUSTMENT OF R19 MAY BE NECESSARY TO INSURE POWER SUPPLY OUTPUT IS IN EXCESS OF 500 MILLIAMPERES AND THE CURRENT RANGE OF THE "CURRENT" CONTROLS IS CORRECT.

6.5.2 VOLTAGE RANGE ADJ. (R26): TO RESET THE D-C OUTPUT VOLTAGE RANGE, TURN "VOLTAGE" CONTROLS TO FULL CLOCKWISE POSITION. ADJUST SCREW SLOT TRIMMER R26 SO THAT OTUPUT VOLTAGE IS SLIGHTLY ABOVE 41 VOLTS. THE PANEL OR AN EXTERNAL METER MAY BE EMPLOYED TO MAKE THIS ADJUSTMENT. TURN BOTH FINE AND COARSE "VOLTAGE" CONTROLS TO FULL COUNTER CLOCKWISE POSITION. THE OUTPUT VOLTAGE RANGE IF PROPERLY ADJUSTED SHOULD RESULT IN AN OUTPUT VOLTAGE OF ZERO OR MAY BE SLIGHTLY NEGATIVE (.2 TO .3 VOLTS).

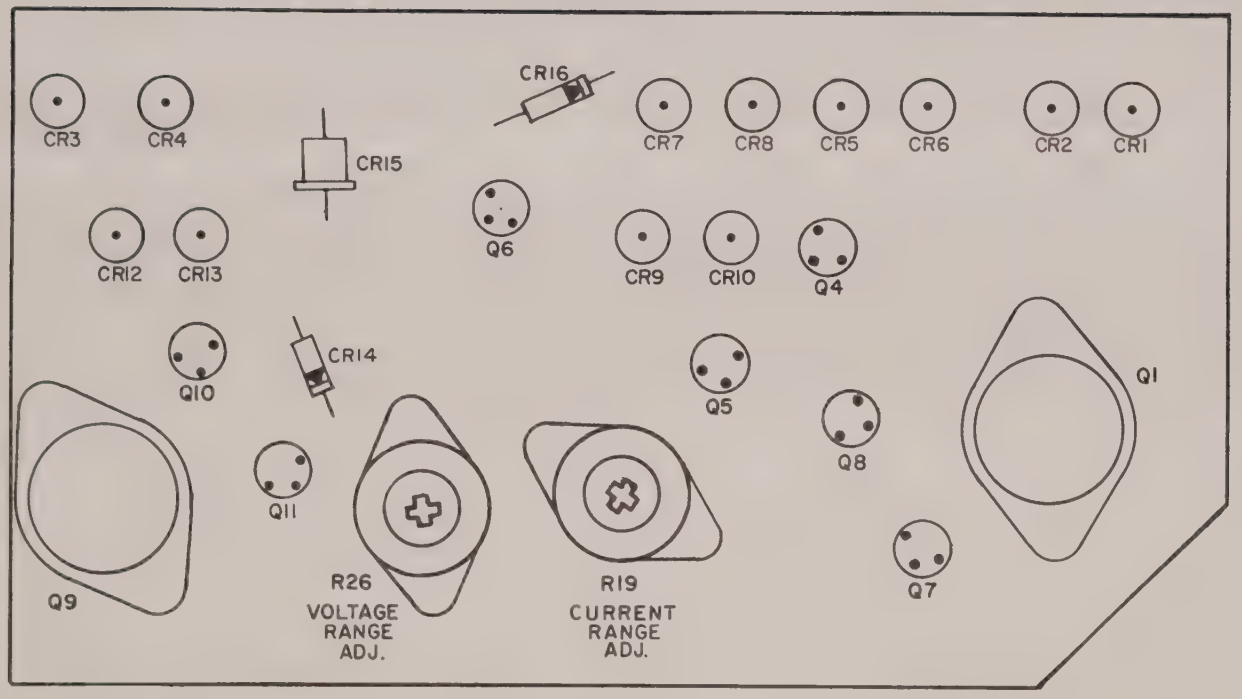
6.5.3 CURRENT METER CALIBRATION: TO INSURE ACCURACY OF THE PANEL METER WHEN SET IN ITS CURRENT READING POSITION THE INSTRUMENT IS CALIBRATED AFTER INSTALLATION IN THE UNIT. IF IT IS DESIRED TO RECALIBRATE THIS INSTRUMENT FOR BETTER ACCURACY AT ANY SPECIFIC POINT IN ITS RANGE OR AFTER REPLACEMENT OF R33, THE METER SHUNT, EMPLOY THE PROCEDURES AS OUTLINED IN PAR. 6.5.1 EXCEPT THAT THE "CURRENT" CONTROLS SHOULD BE ADJUSTED TO PROVIDE THE DESIRED OUTPUT CURRENT AT WHICH THE INSTRUMENT IS TO BE CALIBRATED.

NOTE: BE SURE THAT THE METER IS PROPERLY ZEROED BY MEANS OF THE ZERO ADJUSTING SCREW ON THE INSTRUMENT BEFORE RECALIBRATING.

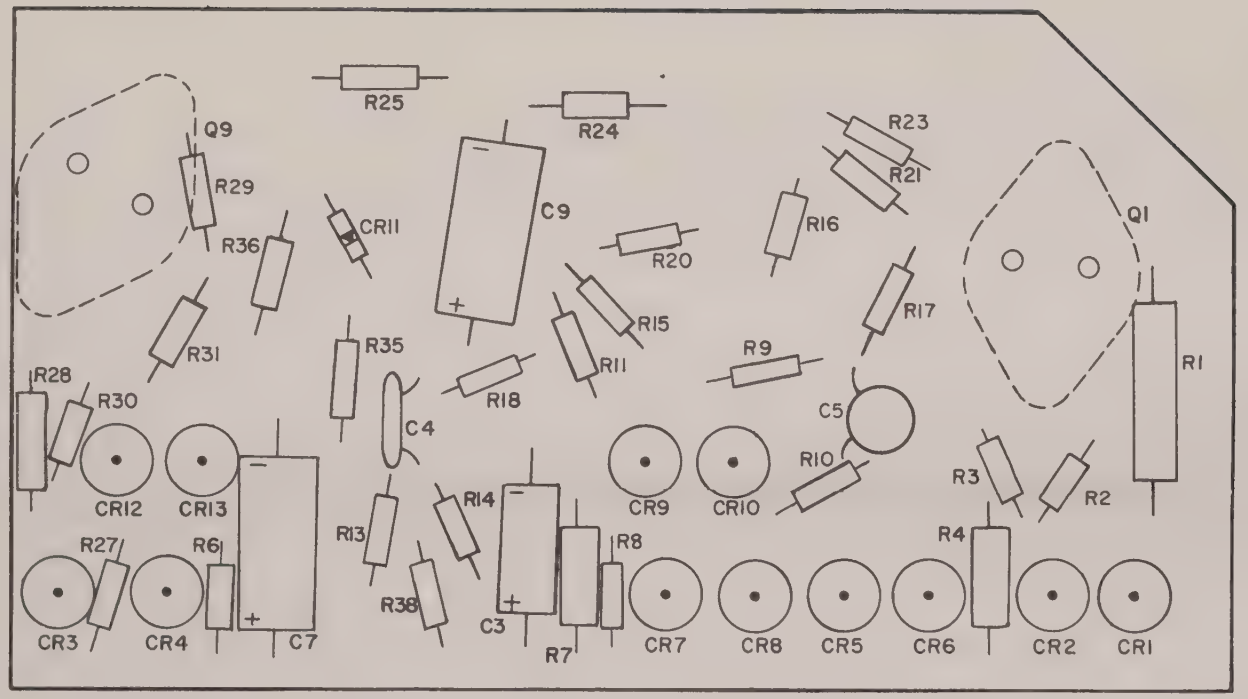
ADJUST R32 SO THAT THE PANEL METER WILL READ CORRECTLY.

DATE	5/15/62	REVISED 2/14/63
APPD.	CS	CS

DWG. NO.	PS-4005-15



AMPLIFIER BOARD - FRONT VIEW



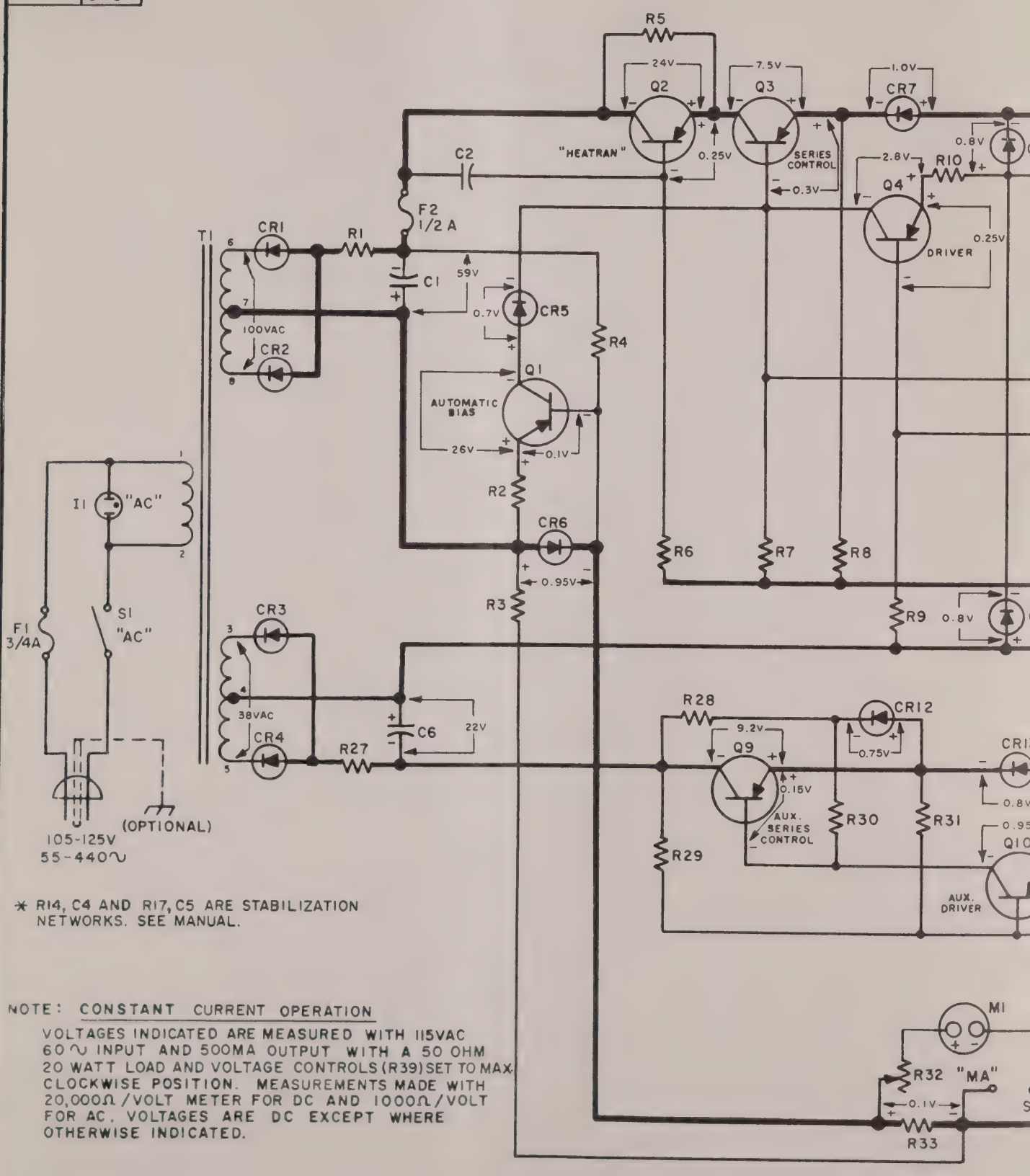
AMPLIFIER BOARD—REAR VIEW

FIGURE I.

LOCATION OF COMPONENTS

MODELS 4005, 4005R & TW-4005

REVISED	APPD.
5/15/62	as
2/14/63	as



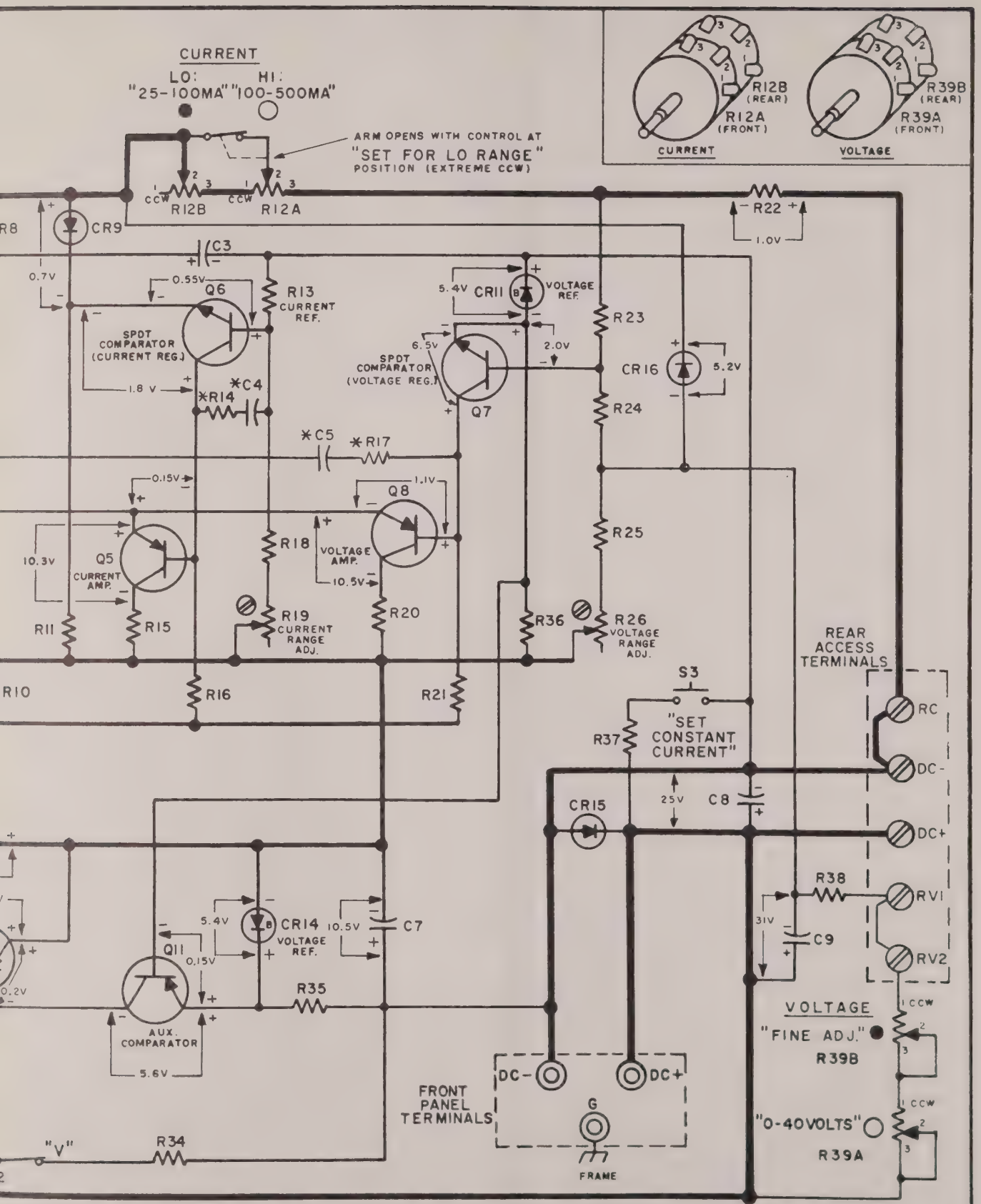
* R14, C4 AND R17, C5 ARE STABILIZATION NETWORKS. SEE MANUAL.

NOTE: CONSTANT CURRENT OPERATION

VOLTAGES INDICATED ARE MEASURED WITH 115VAC 60 ∿ INPUT AND 500MA OUTPUT WITH A 50 OHM 20 WATT LOAD AND VOLTAGE CONTROLS (R39) SET TO MAX. CLOCKWISE POSITION. MEASUREMENTS MADE WITH 20,000Ω/VOLT METER FOR DC AND 1000Ω/VOLT FOR AC. VOLTAGES ARE DC EXCEPT WHERE OTHERWISE INDICATED.

MODEL 4005, 4005R
TRANSISTORIZED POWER SUPPLY

0-40V



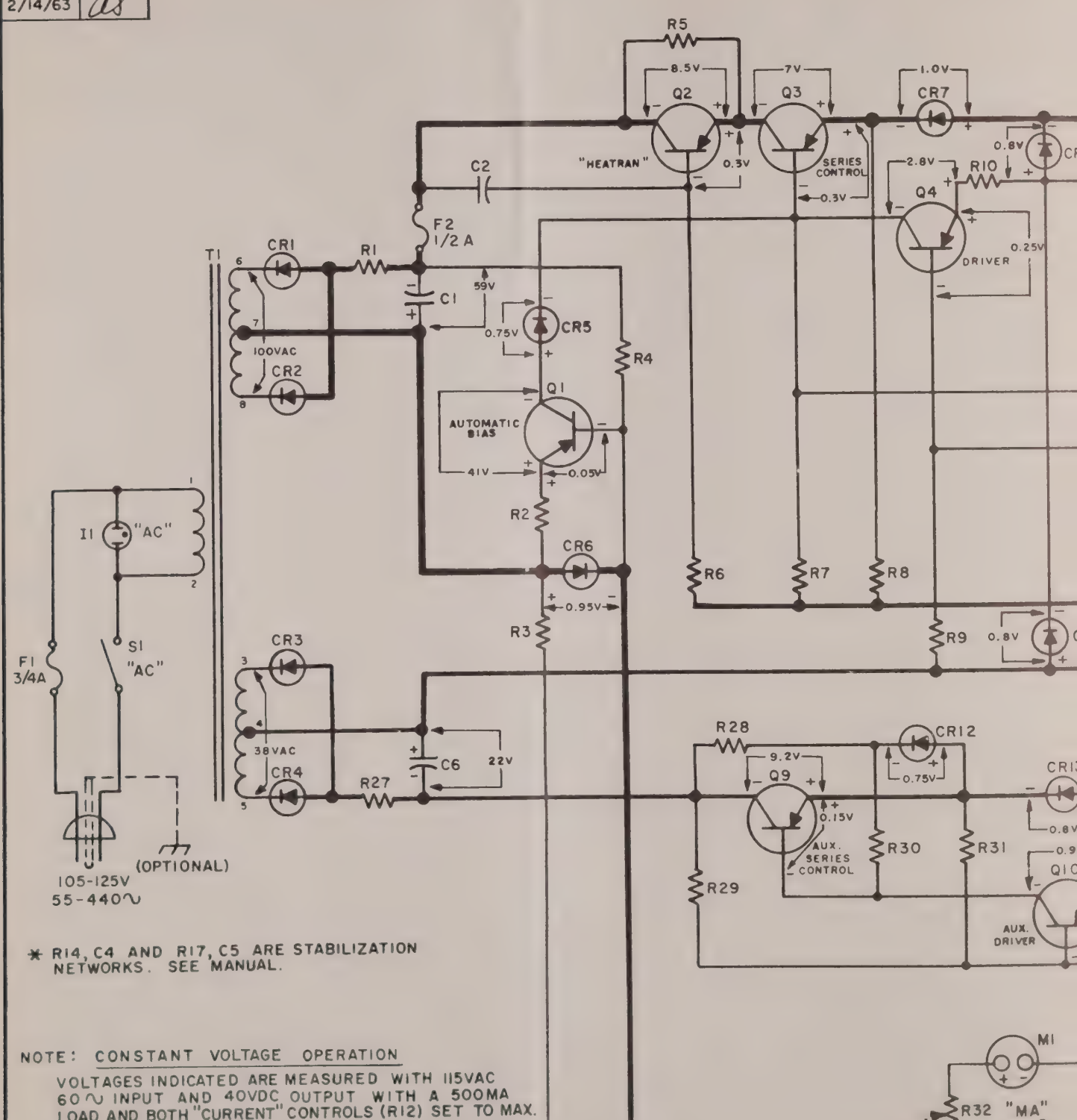
PATENTS PENDING

DRAWN	CHECKED	APP'D
R.O.S.	OS	HK
DATE 7/25/61	DATE 8/1/61	DATE 8/1/61

VDC, 0-500MA (CONSTANT CURRENT OPERATION)

POWER DESIGNS INC.
NEW YORK

REVISED	APPD.
5/15/62	AS
2/14/63	AS

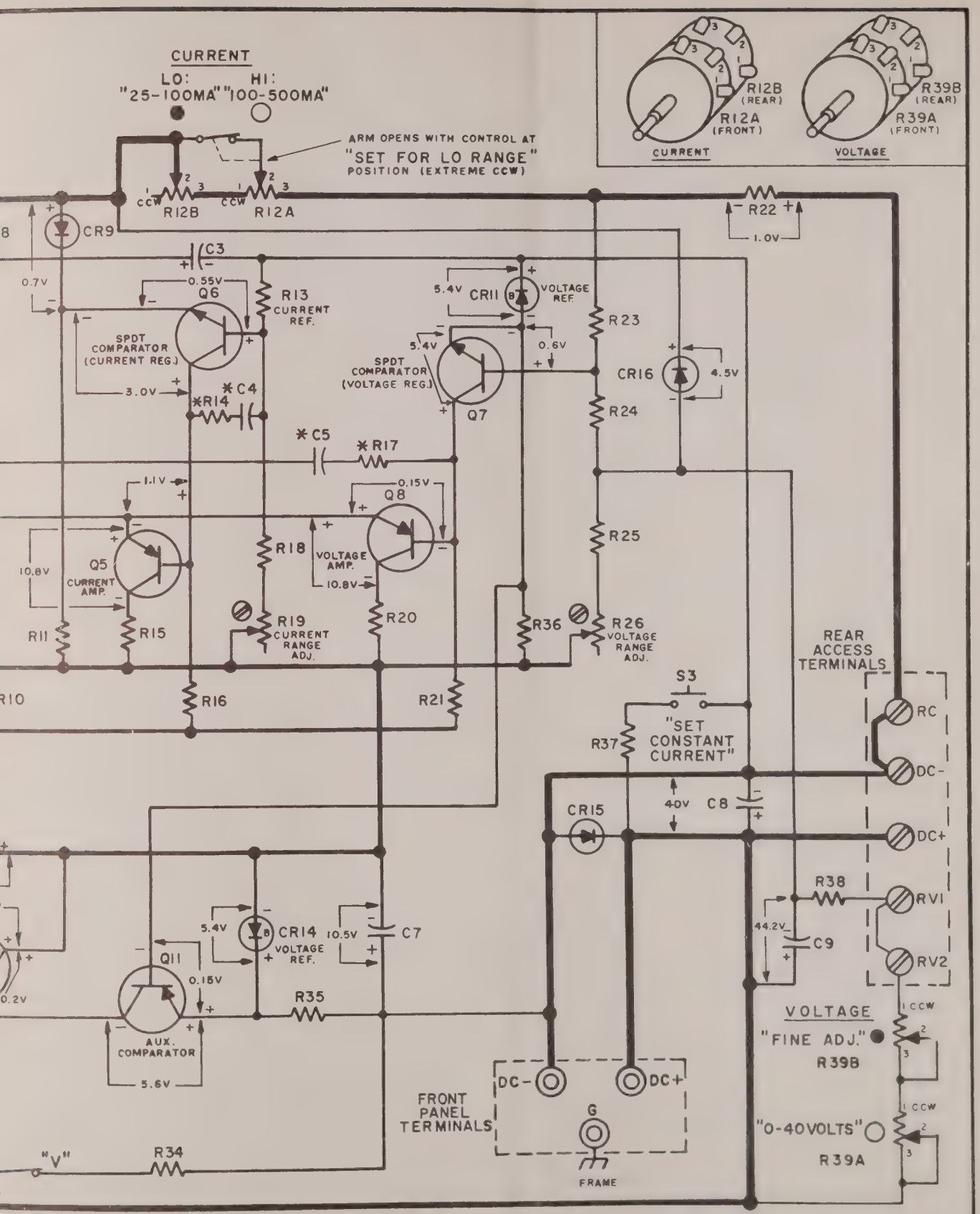


* R14, C4 AND R17, C5 ARE STABILIZATION NETWORKS. SEE MANUAL.

NOTE: CONSTANT VOLTAGE OPERATION

VOLTAGES INDICATED ARE MEASURED WITH 115VAC 60 ~ INPUT AND 40VDC OUTPUT WITH A 500MA LOAD AND BOTH "CURRENT" CONTROLS (R12) SET TO MAX. CLOCKWISE POSITION. MEASUREMENTS MADE WITH 20,000Ω/VOLT METER FOR DC AND 1000Ω/VOLT FOR AC. VOLTAGES ARE DC EXCEPT WHERE OTHERWISE INDICATED.

MODEL 4005,4005R
TRANSISTORIZED POWER SUPPLY



PATENTS PENDING

DRAWN R.Q.S.	CHECKED HR.	APP'D. HR.
DATE 7/25/61	DATE 8/1/61	DATE 8/1/61

DC, 0-500MA (CONSTANT VOLTAGE OPERATION)

POWER DESIGNS INC.
NEW YORK

ELECTRICAL PARTS LIST, MODEL 4005, 4005R

NOTES:
1. ITEMS WHICH BEAR NO FACTORY PART NUMBER ARE STANDARD COMPONENTS AVAILABLE FROM YOUR REGULAR ELECTRONIC PARTS DISTRIBUTOR.
2. IT IS RECOMMENDED THAT REPLACEMENT SEMICONDUCTORS DEVICES BE OBTAINED FROM THE FACTORY. COMMERCIAL EQUIVALENTS MAY HAVE WIDE PARAMETER TOLERANCES WHICH MAY RENDER THEM UNSUITABLE FOR USE IN HIGH GAIN DC AMPLIFIER CIRCUITRY.
3. ALL ELECTROLYTIC CAPACITORS ARE HIGH PURITY FOIL "COMPUTER QUALITY" GRADES WITH A LIFE EXPECTANCY IN EXCESS OF 10 YEARS.

CIRCUIT DESIGNATION	DESCRIPTION	FACTORY PART NO.
C1	CAPACITOR, 350 MFD, 85 VDC, ELECTROLYTIC	CE-47-.85LT
C2	CAPACITOR, 0.1 MFD, 200 VDC, CERAMIC DISC	CC-24-2
C3	CAPACITOR, 8 MFD, 25 VDC, ELECTROLYTIC	CE-21-.25
*C4	CAPACITOR, .01 MFD, 1000 VDC, CERAMIC DISC	CC-13-10
*C5	CAPACITOR, .0033 MFD, 1000 VDC, CERAMIC DISC	CC-12-10
C6	CAPACITOR, 1000 MFD, 25 VDC, ELECTROLYTIC	CE-72-.25LT
C7	CAPACITOR, 35 MFD,25 VDC, ELECTROLYTIC	CE-16-.25
C8	CAPACITOR, 18 MFD, 100 VDC, ELECTROLYTIC	CE-48-1
C9	CAPACITOR, 8 MFD, 100 VDC, ELECTROLYTIC	CE-42-1
CR1, CR2	DIODE, SILICON RECTIFIER, 500 MA, 200 PIV	PT 520
CR3, CR4, CR5 CR6, CR7, CR8 CR9, CR10, CR12 CR13, CR15	DIODE, SILICON RECTIFIER, 0.5A, 100 PIV	F1044P
CR11, CR14	DIODE, SILICON, ZENER, VOLTAGE REFERENCE (5.5V ±.1V)	PS 359A
CR16	DIODE, SILICON, RECTIFIER, 400 MA, 225 PIV	IN645
F1	FUSE, 3/4 AMP, TYPE MDL,"SLO BLO"	------
F2	FUSE, 1/2 AMP, TYPE MDL,"SLO BLO"	------
I1	LAMP, NEON ASSEMBLY WITH SERIES RESISTOR	PLA-2
M1	METER, VOLT-AMMETER, DUAL SCALE, 0-50 VDC/0-500 MA, 2 1/2" RECT.	MVA-98
Q1, Q2, Q3	TRANSISTOR, GERMANIUM POWER, CDT 1356 (CLEVITE)	CDT1356
Q4, Q5, Q8 Q10, Q11	TRANSISTOR, GERMANIUM, 2N360PD (INDUSTRO)	2N360PD
Q6, Q7	TRANSISTOR, SILICON, PLANAR, DUFFUSED, TYPE FS696 (FAIRCHILD)	FS696
Q9	TRANSISTOR, GERMANIUM POWER, CTP1150 (CLEVITE)	CTP1150
R1	RESISTOR, 1 Ω, 5W, 5%, WIREWOUND, AXIAL	RW-010-3DA
R2	RESISTOR, 56 Ω, 1/2W, 10%, COMPOSITION	------

ELECTRICAL PARTS LIST, MODEL 4005, 4005R (CONTINUED)

CIRCUIT DESIGNATION	DESCRIPTION	FACTORY PART NO.
R3	RESISTOR, 68 Ω, ½W, 10%, COMPOSITION	------
R4	RESISTOR, 15K Ω, 1W, 10%, COMPOSITION	------
R5	RESISTOR, 125 Ω, 45W, 5%, WIREWOUND	RWF-1250-P3
R6, R24	RESISTOR, 330 Ω, ½W, 10%, COMPOSITION	------
R7	RESISTOR, 180 Ω, 1W, 10%, COMPOSITION	------
R8, R11, R31	RESISTOR, 1000 Ω, ½W, 10%, COMPOSITION	------
R9, R16, R21	RESISTOR, 3300 Ω, ½W, 10%, COMPOSITION	------
R10	RESISTOR, 2.7 Ω, ½W, 10%, COMPOSITION	------
R12	RESISTOR, VARIABLE, DUAL CONCENTRIC; "A" SECT.: 10 Ω, 4W, 5%, WIREWOUND, TAPERED, OFF POSITION AT FULL CCW: "B" SECT.: 100 Ω, 4W, 5%, WIREWOUND	RWVT-5801
R13	RESISTOR, 330 Ω, ½W, 5%, COMPOSITION	------
*R14	RESISTOR, 680 Ω, ½W, 10%, COMPOSITION	------
R15, R20	RESISTOR, 470 Ω, ½W, 10%, COMPOSITION	------
*R17	RESISTOR, 1.8K, ½W, 10%, COMPOSITION	------
R18	RESISTOR, 2400 Ω, ½W, 5%, COMPOSITION	------
R19	RESISTOR, ADJUSTABLE TRIMMER, 500 Ω, 1.25W, 10% WREWOUND	RWT-501-C4
R22	RESISTOR, 2 Ω, 5W, 5%, WIREWOUND AXIAL	RW-020-3DA
R23	RESISTOR, 270K, ½W, 10%, COMPOSITION	------
R25	RESISTOR, 510 Ω, ½W, 5%, COMPOSITION	------
R26	RESISTOR, ADJUSTABLE TRIMMER, 200 Ω, 1.25W, 10% WIREWOUND	RWT-201-C4
R27	RESISTOR, 10 Ω, ½W, 10%, COMPOSITION	------
R28	RESISTOR, 270 Ω, 1W, 10%, COMPOSITION	------
R29	RESISTOR, 560K, ½W, 10%, COMPOSITION	------
R30	RESISTOR, 220 Ω, ½W, 10%, COMPOSITION	------
R32	RESISTOR, ADJUSTABLE TRIMMER, 50 Ω, 1.25W, 10% WIREWOUND	RWT-500-C4
R33	RESISTOR, METER SHUNT, 0.2 Ω, 10%, 1W PART OF METER BOARD ASSEMBLY	MTB-4005
R34	RESISTOR, 49.9K, 1/4W, 0.5%, PRECISION METAL FILM	RW-49.92-6Q
R35, R36	RESISTOR, 1000 Ω, ½W, 5%, COMPOSITION	------
R37	RESISTOR, 10 Ω, 2W, 10%, COMPOSITION	------
R38	RESISTOR, 430 Ω, ½W, 5%, COMPOSITION	------
R39	RESISTOR, VARIABLE DUAL CONCENTRIC; "A" SECT.: 400 Ω, 4W, 5%, WIREWOUND; "B" SECT.: 100 Ω, 4W, 10%, WIREWOUND	RWVT-5802
S1	SWITCH, TOGGLE SPST	ST-5
S2	SWITCH, TOGGLE SPDT	ST-13
S3	SWITCH, PUSHBUTTON, SPST, MOMENTARY, NORMALLY OPEN	ST-14
T1	TRANSFORMER, POWER	TTM-20

FEBRUARY 1963

ELECTRICAL PARTS LIST, MODEL 4005, 4005R (CONTINUED)

*R14, C4 AND R17, C5 ARE STABILIZATION NETWORKS, VALUES INDICATED ARE DESIGN CENTERS, AND MAY VARY FROM THOSE SHOWN ON THE PARTS LIST.

POWER DESIGNS INC.

"CONTROLLED PARAMETER"

SEMI-CONDUCTOR CODE

EXAMPLE:

REPLACEMENT SEMICONDUCTORS WITH THE SAME POWER DESIGNS TYPE NUMBER AND SUFFIX, ARE DIRECTLY INTERCHANGEABLE.

WARRANTY

POWER DESIGNS INC., WARRANTS TO THE ORIGINAL PURCHASER, EACH INSTRUMENT SOLD BY US, OR OUR AUTHORIZED AGENTS, AND ALL PARTS THEREOF, TO BE FREE FROM DEFECTS IN MATERIAL OR WORKMANSHIP UNDER NORMAL USE AND SERVICE WITHIN THE SPECIFIED RATINGS AND OPERATING CONDITIONS.

ITS OBLIGATION UNDER THIS WARRANTY IS HEREBY LIMITED TO THE REPAIR OR REPLACEMENT OF ANY INSTRUMENT, OR PART THEREOF, WHICH IS RETURNED TO US WITHIN ONE YEAR AFTER DELIVERY, AND WHICH SHALL PROVE AFTER OUR EXAMINATION, TO BE THUS DEFECTIVE.

THIS WARRANTY DOES NOT INCLUDE THE COST OF TRANSPORTATION CHARGES TO AND FROM THE FACTORY AND/OR THE COST OF PACKAGING OR CRATING OF INSTRUMENTS FOR RETURN TO THE FACTORY UNLESS SUCH INSTRUMENT IS RETURNED WITHIN THIRTY (30) DAYS FROM DATE OF ORIGINAL SHIPMENT AS SHOWN ON THE PACKING LIST OR SHIPPING DOCUMENTS, AND PRIOR WRITTEN AUTHORIZATION FOR SUCH COSTS IS OBTAINED FROM THE FACTORY.

THE REPAIR OR REPLACEMENT OF AN INSTRUMENT OR ANY PART THEREOF DOES NOT VOID OR EXTEND THE ORIGINAL WARRANTY.

POWER DESIGNS INC. RESERVES THE RIGHT TO DISCONTINUE ANY INSTRUMENT WITHOUT NOTICE, OR TO MAKE MODIFICATIONS IN DESIGN AT ANY TIME WITHOUT INCURRING ANY OBLIGATION TO MAKE THESE MODIFICATIONS IN INSTRUMENTS PREVIOUSLY SOLD.

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